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16. ABSTRACT

Macroinvertebrate and water chemistry samples were taken at seven stations in the Yellowstone River between August 1973 and August 1974. The stations were located between Gardiner and Laurel, Montana. Macroinvertebrate samples were collected on six, and water chemistry samples on eight occasions, at 1-2 month intervals, throughout the year. The majority of macroinvertebrate species collected were found to be common throughout the area studied; however, certain species were found only at the upper and others only at the lower stations. The greatest incident of change appeared to be between the stations located where the river underwent a transition between a narrow, canyon-bound mountain stream to a relatively broader, meandering plains river. The chemical analyses data show no water quality degradation; all concentrations were well below levels considered to be harmful to aquatic organisms. The observed differences in the macroinvertebrate community are believed to be attributable to ecological factors other than water chemistry. Changes in river and riverbed morphology, primary and secondary productivity, and physical parameters of water quality (e.g., temperature, turbidity) are believed to affect macroinvertebrate distribution in the upper Yellowstone River.

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UPPER YELLOWSTONE RIVER, MONTANA: MACROINVERTEBRATE DISTRIBUTION AND WATER ANALYSIS 1973-1974

Robert V. Thurston, Robert J. Luedtke, and Rosemarie C. Russo

INTRODUCTION

The Yellowstone River originates near the Continental Divide south of Yellowstone National Park in Wyoming. It flows in a northerly direction through Yellowstone Park to Livingston, Montana, after which it assumes a northeasterly course to its confluence with the Missouri River in North Dakota.

Within the Park boundary, the Yellowstone River receives pollution in the form of partially treated domestic sewage (2). The reach of the Yellowstone River between Gardiner and Laurel receives no major industrial pollution but does receive inputs from domestic sewage and agricultural runoff. Hayes and Willems (3) reported no significant degradation of water quality and only a slight reduction in the percent of sensitive macroinvertebrates in the stretch between Tower Junction and Laurel.

Stadnyk (9) studied the ecological factors affecting stonefly distribution in the upper Yellowstone River in Montana. Based on his study and the predicted importance of additional baseline information, the present study involved sampling of the total macroinvertebrate community concurrent with more detailed water chemistry analysis. This information may be useful in determining future effects of development and utilization of the Yellowstone River.

METHODS AND MATERIALS

Macroinvertebrates

Seven sampling stations were established in the Yellowstone River in August, 1973 (Figure 1). Samples were taken in riffles, which had medium to large (10-20 cm) cobble, and water velocity of 30 to 40 cm/sec during low flow as measured with a Gurley 625-F current meter. Water depths averaged approximately 30 cm. Mean discharge for the water year (October, 1973 to September, 1974) was 4,191 cfs with a maximum of 28,500 cfs (June 17) and a minimum of 600 cfs (January 10) (13).

Macroinvertebrate samples were collected in 1973 on 9-10 August, 20 September, and 29 November; and in 1974 on 11 February, 22 April, and 22 August. A modified Hess sampler (15) was used to take a 0.28 m^2 sample from each station. Organisms were identified to species when possible; in some cases identifications of taxa were confirmed by recognized authorities. Species diversity indices by Margalef (5), Simpson (8), and Patten (7) as modified by Hamilton (4), were utilized in analyses of count data.

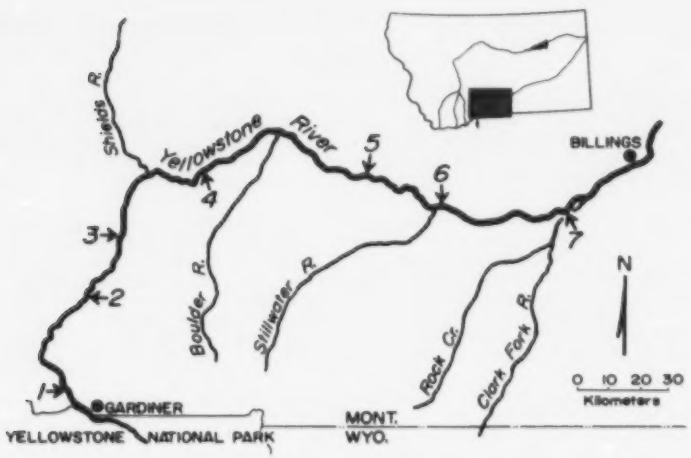

Figure 1. Yellowstone River Sampling Stations.

Water Chemistry

Water samples for chemical analyses were collected in 1973 on 9-10 August, 20 September, and 29 November; and in 1974 on 11 February, 22 April, 26 June, 30 July and 22 August. Samples collected from August, 1973, through April, 1974, were not filtered prior to analysis. A portion of each sample collected in June, July, and August, 1974, was filtered through a 0.45μ filter for the ammonia, nitrate, nitrite, and trace metal analyses; samples were preserved with nitric acid for subsequent trace metal analyses.

Temperature and specific equivalent conductance (S.E.C.) were measured with a YSI Model 33 S.C.T. meter, and S.E.C. values were corrected to 25° C. Measurement of pH was made with Beckman Chem-mate or Phasar-I meters. Iron and zinc were determined using a Varian Model 1100 flame atomic absorption (AA) spectrophotometer; copper and cadmium were determined using a Varian Model AA-5 spectrophotometer equipped with a Woodriff furnace (16, 17) for flameless AA. Nitrite was analyzed by the method described in Strickland and Parsons (10). All other chemical analyses were performed according to procedures described in APHA (1); for dissolved oxygen the azide

modification of the iodometric method was used, with phenylarsine oxide substituted for sodium thiosulfate. All colorimetric measurements were made using a Varian 635 uv-vis spectrophotometer.

RESULTS

Results for species diversity, number of insect species, total numbers of insects, and seasonal changes in the number of insect species are presented in Tables I-III and Figure 2. A

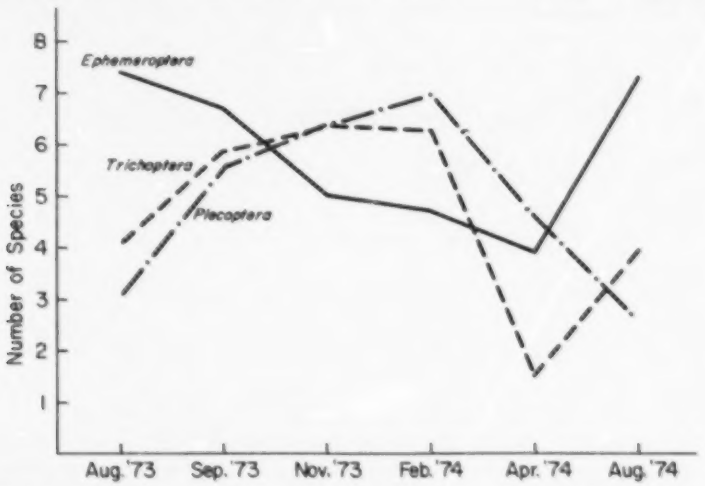

Figure 2. Seasonal Changes in Aquatic Insects, Upper Yellowstone River 1973-1974.

species checklist with frequency of occurrence and abundance is shown in Table IV. Values reported in Tables I-III and Figure 2 are mean values of all samples collected at each station (6 samples for each station). A summary of the means and ranges found for 8 samples at each station for the chemical parameters is given in Table V. A complete tabulation for each sampling date of water chemistry analyses and raw macroinvertebrate data counts is available in a project report (11).

DISCUSSION

Small differences in the species composition of the benthic macroinvertebrate community were observed along the reach of Yellowstone River investigated in this study. The majority of species collected were found to be common throughout the area studied. However, certain species found at upstream

Table I. Species Diversity* Index Values, Upper Yellowstone River (Montana), August 1973 - August 1974

(Values given are means, with ranges in parentheses)

Sampling Stations	Shannon Index (4,7)	Shannon's Redundancy (4,7)	Margalef Index (5)	Simpson Index (8)	Mean No. Taxa
YR-1	2.64 (2.19-3.44)	.40 (.26-.51)	2.76 (2.11-3.54)	.26 (.13-.37)	17.7
YR-2	2.52 (2.27-2.96)	.38 (.29-.45)	2.11 (1.49-2.44)	.23 (.16-.28)	16.2
YR-3	2.56 (1.70-3.11)	.39 (.29-.57)	2.29 (1.78-2.80)	.25 (.16-.41)	15.7
YR-4	2.50 (1.44-3.15)	.41 (.29-.63)	2.31 (1.30-2.92)	.29 (.15-.54)	15.8
YR-5	2.89 (2.13-3.46)	.30 (.21-.48)	2.48 (2.02-3.30)	.20 (.12-.31)	15.8
YR-6	2.72 (1.54-3.32)	.34 (.22-.55)	2.43 (1.31-3.40)	.24 (.12-.50)	15.0
YR-7	2.67 (2.01-3.43)	.37 (.19-.43)	2.65 (1.52-3.54)	.24 (.12-.34)	16.2

*Diversity values based on taxa identified to the generic level.

stations were not collected at downstream sampling sites, e.g., *Baetis* sp. B, *Epeorus longimanus*, *Ephemerella doddsi*, *Ephemerella tibialis*, *Athripsodes* sp., *Nemoura cinctipes* and *Pteronarcys californica*. Similarly, some species collected at lower stations were not found at upper sites, e.g., *Traverella albertana*, *Tricorythodes minutus* and *Helicopsyche borealis*.

The greatest increment of change appears to be between Stations 2 and 4, which corresponds to a transition in the river's character from a narrow canyon-bound mountain stream to a relatively broader meandering plains river. The development of the flood plain for agricultural purposes below Station 1 may also affect the faunal composition of the river.

No apparent trends were found for values of species diversity and percent composition. There appeared to be a reduction in numbers of species and total numbers of insects in a downstream direction (Tables II and III). Seasonal fluctuations in

Table II. Numbers of Aquatic Insect Species per Square Meter, Upper Yellowstone River (Montana), August 1973 - August 1974
(Values given are means, with ranges in parentheses)

Sampling Stations	Aquatic Insect Species*					
	Ephem.	Plec.	Trich.	Cole.	Dipt.	Totals
YR-1	7.8 (4-11)	4.7 (2-8)	5.0 (2-8)	0.7 (0-3)	1.8 (1-2)	20.0
YR-2	6.5 (4-9)	5.5 (4-7)	3.8 (2-5)	0.8 (0-2)	2.8 (2-5)	19.4
YR-3	4.7 (3-6)	4.8 (2-8)	5.2 (2-7)	0.5 (0-2)	3.2 (1-4)	18.4
YR-4	5.5 (3-9)	4.5 (2-7)	4.7 (0-7)	0.7 (0-2)	2.2 (0-3)	17.6
YR-5	5.2 (3-8)	4.7 (3-7)	5.3 (3-7)	0.3 (0-1)	1.7 (1-2)	17.2
YR-6	5.3 (3-7)	5.0 (3-7)	4.5 (1-6)	0.5 (0-2)	0.8 (0-2)	16.1
YR-7	5.8 (4-7)	4.7 (2-7)	5.5 (1-8)	1.0 (0-2)	1.2 (0-2)	18.2

*Ephem.=Ephemeroptera; Plec.=Plecoptera; Trich.=Trichoptera; Cole.=Coleoptera; Dipt.=Diptera (exclusive of Chironomidae).

Montana Academy of Sciences 36: 37-49, 1976

Table III. Total Numbers of Aquatic Insects per Square Meter, Upper Yellowstone River (Montana), August 1973 - August 1974
(Values given are means, with ranges in parentheses)

Sampling Stations	Aquatic Insects*					
	Ephem.	Plec.	Trich.	Cole.	Dipt.	Totals
YR-1	1152 (147-3163)	289 (72-641)	592 (18-1792)	11 (0-30)	666 (169-1131)	2710
YR-2	2409 (797-5318)	771 (176-2372)	1458 (32-2525)	4 (0-11)	1205 (650-2904)	5847
YR-3	1041 (12-3210)	751 (25-3517)	1251 (8-2932)	3 (0-8)	697 (488-936)	3743
YR-4	1033 (356-3454)	623 (107-1315)	698 (0-1224)	4 (0-15)	532 (108-1874)	2890
YR-5	387 (244-629)	351 (245-546)	782 (12-2212)	2 (0-7)	129 (25-237)	1651
YR-6	551 (259-1010)	139 (86-247)	589 (7-1601)	3 (0-11)	208 (4-575)	1490
YR-7	614 (173-1106)	248 (54-452)	302 (4-884)	7 (0-18)	163 (29-423)	1334

*Ephem.=Ephemeroptera; Plec.=Plecoptera; Trich.=Trichoptera; Cole.=Coleoptera; Dipt.=Diptera.

numbers of species of Ephemeroptera, Plecoptera and Trichoptera were also evident (Figure 2), and are attributable, in part, to insect life cycle changes as they affected collection techniques.

The chemical analytical data show no water quality degradation. All concentrations are well below levels considered harmful to aquatic organisms (6). U.S. Geological Survey water quality data (available for Station 1, Corwin Springs, for August, October, and December, 1973) show generally similar values to those reported here (12, 14).

The observed differences in the macroinvertebrate community are therefore believed to be attributable to ecological factors other than water chemistry. Changes in river and riverbed morphology, primary and secondary productivity and physical parameters of water quality (e.g., temperature, turbidity) are believed to affect macroinvertebrate distribution in the upper Yellowstone River.

ACKNOWLEDGMENT

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Table IV. Checklist, Number of Occurrences, and Abundance* of Aquatic Macroinvertebrates Upper Yellowstone River (Montana), August 1973 - August 1974

	Benthos Sampling Stations						
	1	2	3	4	5	6	7
Ephemeroptera							
Baetidae							
Baetis parvus Dodds	6-197	6-923	6-133	6-675	6-118	6-101	6-190
Baetis sp. A	6-25	4-72	3-54	3-230	3-83	3-101	3-115
Baetis sp. B	1-7	-	-	-	-	-	-
Ephemerellidae							
Ephemerella (Drunella) doddsi Needham	3-7	2-4	-	1-4	-	-	-
E. (Drunella) grandis grandis McD.	5-11	5-7	5-14	1-29	1-4	-	-
E. (Timpanoga) hecuba hecuba Eaton	-	1-4	-	-	-	-	-
E. (Caudatella) heterocaudata heterocaudata McD.	-	2-7	-	-	-	-	-
E. (Caudatella) hystrix Traver	1-4	1-4	-	-	-	-	-
E. (Ephemerella) inermis Eaton	4-1109	5-528	5-722	5-57	5-25	4-93	4-57
E. (Attenuata) margarita Needham	2-18	-	2-36	2-72	2-39	2-50	2-14
E. (Serratella) tibialis McD.	2-29	2-251	2-43	1-11	-	-	-
Heptageniidae							
Epeorus (Iron) albertae (McD.)	-	1-14	-	-	-	-	-
Epeorus (Iron) longimanus (Eaton)	1-4	1-4	-	-	-	-	-
Heptagenia elegantula (Eaton)	5-36	1-4	1-4	3-4	3-18	4-36	6-7
Rhithrogena hageni Eaton	6-108	6-894	4-352	6-147	6-129	6-140	6-151
Leptophlebiidae							
Paraleptophlebia heteronea (McD.)	2-7	-	-	-	-	-	1-4
Traverella albertana (McD.)	-	-	-	-	-	-	1-7
Siphlonuridae							
Ameletus sp.	3-7	-	-	3-4	2-4	4-39	2-7
Tricorythidae							
Tricorythodes minutus Traver	-	-	-	2-18	3-90	3-248	4-230
Plecoptera							
Chloroperlidae							
Alloperla sp.	3-22	4-75	4-97	4-481	4-118	4-126	3-90

Plecoptera (cont'd)							
Nemouridae							
Brachyptera sp.	-	-	-	1-4	1-4	-	-
Capnia sp.	-	1-7	-	1-4	-	-	1-4
Isocapnia sp.	1-4	-	-	-	-	-	-
Nemoura (*Zapada*) *cinctipes* Banks	1-4	1-11	-	-	-	-	-
Nemoura sp.	1-4	2-22	-	-	-	-	-
Perlidae							
Acroneuria (*Hesperoperla*) *pacifica* Banks	6-43	2-4	-	-	-	1-4	-
Claassenia sabulosa (Banks)	-	3-11	4-4	3-11	5-14	4-11	6-65
Perlodidae							
Arcynopteryx (*Skwala*) *parallela* (Frison)	1-7	-	-	-	-	3-4	1-4
Isogenus (*Isogenoides*) *elongatus* Hagen	4-54	5-50	4-18	5-47	6-136	6-68	6-79
Isogenus sp.	3-68	3-194	3-197	3-61	3-11	2-22	3-4
Isoperla mormona Banks	3-176	4-768	4-851	4-269	3-50	4-14	3-43
Pteronarcidae							
Pteronarcella badia (Hagen)	1-4	5-32	5-7	6-39	6-86	5-18	5-32
Pteronarcys californica Newport	6-101	3-36	3-11	-	-	-	-
Trichoptera							
Brachycentridae							
Amiocentrus aspilus (Ross)	-	-	1-4	-	-	-	-
Brachycentrus sp.	-	4-32	6-32	5-251	6-194	4-54	3-25
Glossosomatidae							
Glossosoma sp.	4-18	2-11	3-14	1-18	2-25	2-7	2-7
Helicopsychidae							
Helicopsyche borealis (Hagen)	-	-	-	-	-	-	1-32
Hydropsychidae							
Arctopsyche sp.	5-39	3-136	4-90	5-32	5-22	4-18	5-25
Cheumatopsyche sp.	3-22	3-104	4-276	4-54	5-93	5-183	4-115
Hydropsyche sp.	6-460	6-847	5-768	5-291	5-521	5-363	5-208
Hydroptilidae							
Hydroptila sp.	1-14	-	4-72	1-4	3-18	4-108	2-7
Lepidostomatidae							
Lepidostoma sp.	4-39	4-718	4-406	3-348	3-61	3-14	2-4
Leptoceridae							
Athripsodes sp.	2-4	-	-	1-4	-	-	-

Trichoptera (cont'd)							
Psychomyiidae							
Psychomyia sp.	5-54	1-11	-	3-4	3-7	-	2-4
Coleoptera							
Dryopidae							
Helichus striatus LeConte	-	-	-	-	1-7	-	-
Dytiscidae							
Oreodytes septentrionalis Gyllenhal	1-4	1-4	2-4	2-7	-	-	2-11
Elmidae							
Optioservus divergens (LeConte)	2-7	-	-	-	-	1-7	-
Optioservus quadrimaculatus (Horn)	3-11	2-4	-	1-4	-	1-4	3-4
Zaitzevia parvula (Horn)	1-4	2-4	1-4	1-4	1-4	1-4	1-4
Diptera							
Blephariceridae	-	-	1-7	-	-	-	-
Chironomidae	6-628	6-625	6-564	6-477	6-101	6-187	6-144
Empididae	-	-	1-7	-	-	-	-
Heleidae							
Palpomyia sp.	-	2-4	-	-	-	-	-
Rhagionidae							
Atherix variegata Walker	4-29	2-11	5-65	5-18	5-14	-	2-7
Simuliidae							
Simulium sp.	3-14	6-524	6-57	2-4	-	1-4	2-7
Tipulidae							
Dicranota sp.	-	1-4	1-7	-	-	-	-
Hexatoma sp.	4-18	6-47	4-22	5-39	5-14	4-29	3-22
Rhadomastix sp.	-	-	1-4	-	-	-	-
Oligochaeta	1-11	3-7	3-4	3-7	1-18	-	2-22

*Abundance = mean number per occurrence.

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Table V. Upper Yellowstone River
(Values given are means,

Sample Station	Temp. °C.	D.O. mg/l	pH	S.E.C. µmhos	Alk. mg/l	Cadmium µg/l	Calcium mg/l	Chloride mg/l
1			7.99	188	60	0.02	13.9	9.6
	(3.1-	(8.3-	(7.50-	(87-	(36-	(0.01-	(7.5-	(4.8-
	18.5)	12.9)	8.95)	299)	90)	0.04)	23.0)	17.8)
2			8.22	190	67	0.02	16.2	8.3
	(1.9-	(8.7-	(7.74-	(83-	(36-	(<0.01-	(7.5-	(1.7-
	19.0)	12.6)	8.80)	292)	92)	0.05)	25.3)	15.0)
3			8.24	186	67	0.02	15.5	7.8
	(0.8-	(8.6-	(7.75-	(77-	(36-	(<0.01-	(7.1-	(1.6-
	19.0)	13.5)	8.75)	280)	93)	0.06)	25.3)	14.2)
4			8.08	218	90	0.02	22.4	6.6
	(2.0-	(8.8-	(7.60-	(98-	(46-	(<0.01-	(9.9-	(1.9-
	19.0)	12.8)	8.45)	309)	118)	0.04)	31.7)	10.9)
5			8.16	240	99	0.03	25.4	5.9
	(1.0-	(8.1-	(7.79-	(104-	(49-	(0.01-	(11.9-	(1.7-
	20.0)	11.9)	8.50)	334)	134)	0.05)	35.6)	9.3)
6			8.23	234	98	0.02	24.7	5.4
	(0.0-	(7.8-	(7.91-	(107-	(49-	(<0.01-	(11.9-	(1.7-
	21.0)	11.7)	8.80)	328)	123)	0.05)	32.8)	8.4)
7			8.17	238	99	0.02	25.1	5.0
	(0.0-	(7.8-	(7.88-	(104-	(47-	(<0.01-	(11.9-	(1.3-
	22.0)	11.9)	8.80)	324)	124)	0.08)	34.0)	7.5)

Chemical Analysis Summary, August 1973 - August 1974
with ranges in parentheses)

Copper mg/l	Hardness mg/l	Iron mg/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l	PO_4-P mg/l	Zinc mg/l
0.005 (0.002-0.009)	54 (30-86)	0.18 (<0.07-0.36)	0.18 (0.06-0.42)	0.01 (0.00-0.01)	0.16 (0.00-0.34)	0.04 (0.02-0.09)	0.016 (<0.010-0.053)
0.005 (0.002-0.010)	64 (30-93)	0.18 (<0.07-0.35)	0.11 (0.02-0.31)	0.00 (0.00-0.01)	0.14 (0.00-0.29)	0.04 (0.02-0.10)	0.011 (<0.010-0.017)
0.005 (<0.002-0.010)	66 (29-88)	0.20 (<0.07-0.53)	0.12 (0.01-0.32)	0.00 (0.00-0.01)	0.12 (0.00-0.26)	0.03 (0.02-0.08)	0.015 (<0.010-0.039)
0.004 (0.003-0.006)	84 (38-118)	0.14 (<0.07-0.31)	0.12 (0.02-0.32)	0.00 (0.00-0.01)	0.04 (0.00-0.18)	0.03 (0.01-0.09)	0.012 (<0.010-0.024)
0.005 (0.003-0.010)	93 (43-128)	0.21 (<0.07-0.38)	0.16 (0.01-0.41)	0.00 (0.00-0.01)	0.03 (0.00-0.16)	0.03 (0.01-0.07)	0.011 (<0.010-0.017)
0.005 (0.002-0.008)	92 (42-121)	0.16 (<0.07-0.25)	0.14 (0.01-0.38)	0.00 (0.00-0.01)	0.04 (0.00-0.16)	0.03 (0.01-0.07)	0.011 (<0.010-0.017)
0.006 (0.003-0.011)	92 (42-124)	0.15 (<0.07-0.27)	0.13 (0.03-0.43)	0.00 (0.00-0.01)	0.04 (0.00-0.17)	0.02 (0.00-0.06)	0.012 (<0.010-0.022)